

Applicants affirm the telephone election of April 11, 2000 in which claims 1-24 were elected. It is understood that claim 25-26 are withdrawn from prosecution. Applicant reserves the right to file a divisional application on claims 25-26.

Attached to this amendment are brief abstracts of the references cited in the Information Disclosure Statement of July 6, 1999.

As indicated above minor informalities in the claims have been corrected. It is respectfully submitted that the rejection of the claims under 35 U.S.C. § 112 second paragraph no longer applies. Therefore it is respectfully requested that the Examiner withdraws the rejection to the claims under 35 U.S.C. § 112 second paragraph.

Claim 1 claims a photomask and claim 16 claims a photomask fabrication method including a transparent substrate, a hollow section formed on the surface of the transparent substrate, a shade pattern formed in the hollow section and reflection preventing sections or films.

Through the structure and method having reflection preventing sections or films, as claimed in claims 1 and 16, the present invention provides a photomask and method of making thereof which has a large mechanical strength and has a decreased structural defects in the shade pattern. The prior art does not show, teach or suggest a photomask and method thereof having reflection preventing sections or films as claimed in claims 1 and 16.

Claim 2 claims a photomask and claim 17 claims a photomask fabrication method in which a shade pattern is formed on a surface on a surface of a transparent substrate and a planarized phase shift pattern is selectively formed on the shade pattern and the transparent substrate.

Through the structure and method of the present invention forming a shade pattern on the surface of a transparent substrate and selectively forming a planarized phase shift pattern thereon, as claimed in claims 2 and 17, the present invention provides a photomask and fabrication method thereof in which a phase shift pattern has a uniform thickness so that the contrast of an optical image is increased. The prior art does not show, teach or suggest a shade pattern formed on a surface of a transparent substrate and a planarized phase shift pattern selectively formed thereon as claimed in claims 2 and 17.

Claim 5 claims a photomask and claim 20 claims a photomask fabrication method in which a shade pattern is formed in a hollow section of a transparent substrate and a planarized phase shift pattern is selectively formed on the transparent substrate. Thus, the present invention provides a photomask and a fabrication method thereof in which it is possible to increase the contrast of an optical image when semiconductor integrated circuits are fabricated using the phase shift photomask. The prior art does not show, teach or suggest a planarized phase shift pattern formed on the transparent substrate as claimed in claims 5 and 20.

Claim 7 claims a photomask and claim 22 claims a photomask fabrication method in which a transparent substrate is selectively etched to form a phase shift pattern. Thus, the present invention provides a photomask and fabrication method thereof in which it is possible to increase the contrast of an optical image when the photomask is used. The prior art does not show, teach or suggest forming a phase shift pattern as claimed in claims 7 and 22.

Claims 1, 2, 5, 7, 9-11, 14, 20 and 22 were rejected under 35 U.S.C. § 102(b) as being anticipated by Hur et al. (U.S. Patent No. 5,437,927).

In addition, claims 17-19, 21 and 23 were rejected under 35 U.S.C. § 103 as being unpatentable over Hur et al.

Applicant respectfully traverses the Examiner's rejection of the claims under 35 U.S.C. § 102(b) and under 35 U.S.C. § 103. The claims have been reviewed in light of the Office Action, and for reasons which will be set forth below, it is respectfully requested that the Examiner withdraws the rejection to the claims and allows the claims to issue.

Hur et al. appears to disclose coating a transparent substrate 21 with a layer of photoresist material 22 and then forming a photoresist pattern. With the pattern photoresist layer 22 as a mask, the revealed substrate 21 is etched to form a trench 23. Upon removal of the photoresist layer 22, a layer of chrome 24 is deposited over the substrate 21. The layer of chrome 24 is etched back and then an opaque layer remains in the trench 23. A layer of oxide 26 with a layer of photoresist material 27 thereon is formed. The photoresist layer 27 is patterned and the oxide layer 26 is exposed at the portion corresponding to the partially removed photoresist layer. With the pattern photoresist layer 27 as a mask, the exposed oxide layer 26 is etched away to form a phase shift mask 28 over the substrate 21 which remains unetched between the trenches and then the photoresist layer is removed. (Col 3, lines 20-51). In Figures 5A to 5H, after the phase shifting layer 28 is formed, the quartz substrate 21 underneath the phase shifting layer 28 is etched. The phase shifting layer 28 and opaque layer 25 serve as the dry etch mask to form a groove on both sides of the trench 23. The quartz substrate 21 is etched to the optimize thickness for maximizing

the light sensitivity. (Col 4, lines 32-47). FIG. 9A and 9F are the process steps of the mask in which the transparent quartz substrate 21 is coated the photoresist film 22 to form the photoresist pattern of width W through the well-known photolithographic process (FIG. 9A). The patterned photoresist film 22 acts as the mask to form a trench 23 by etching the substrate 21 (FIG. 9B). Upon removal of the photoresist pattern 22, a layer of chrome 24 is deposited over the substrate 21 to fully fill the trench 23 (FIG. 9C). The physical and chemical polishing step makes the opaque layer 25 as high as the quartz substrate, thereby maintaining the smoothed level throughout the whole surface for planarization (FIG. 9D). Over the entire surface it is formed an oxide layer 26 on which a photoresist film is coated again. The coated photoresist film 27 is patterned to form a photoresist pattern by photolithography (FIG. 9E). Upon removal of the photoresist layer 27 after the formation of the phase shifting layer, it is obtained the edge enhancement phase shifting mask of the full filled trench with the opaque layer. (Col 5, lines 2-24).

Thus, Hur et al. merely discloses in Fig. 3 and 5 an opaque layer 25 formed in a trench 23. Nothing in Hur et al. shows, teaches or suggests reflection preventing sections each formed according to one of a) on the shade section, b) under the shade section and c) on and under the shade section as claimed in claims 1 and 16. Rather, Hur et al. merely discloses an opaque layer 25 residing in a trench 23. No other layer is formed on, under or on and under the layer 25 of Hur et al.

Additionally, Hur et al. merely discloses phase shifting layer 28. Nothing in Hur et al. shows, teaches or suggests planarizing the surface of a phase shift pattern as claimed in

claims 2, 5, 17 and 20. Rather, Hur et al., merely discloses a phase shifting layer 28 which is not planarized.

Finally, Hur et al. merely discloses in FIG. 9 that after a chrome layer 24 is deposited to fill the trench 23, physical and chemical polishing takes place and thereafter an oxide 26 is coated and a photoresist film 27 are respectively coated and patterned and thereafter a phase shifting layer is formed. Thus, nothing in Hur et al. shows, teaches or suggests a) a phase shift pattern formed by a transparent substrate or b) selectively etching the transparent substrate as claimed in claim 22. Rather Hur et al. merely discloses etching the oxide 26 in order to form the phase shift pattern 28. The substrate 21 of Hur et al. is not etched and does not form the phase shift pattern.

Since nothing in Hur et al. shows, teaches or suggests a) reflection preventing sections as claimed in claims 1 and 16, b) a planarized phase shift pattern as claimed in claims 2, 5, 17 and 20, d) a phase shift pattern formed by the transparent substrate as claimed in claim 7 or e) selectively etching a transparent substrate as claimed in claim 22, it is respectfully requested that the Examiner withdraws the rejection to claims 1, 2, 5, 7, 20 and 22 under 35 U.S.C. § 102(b) and withdraws the rejection to claim 17 under 35 U.S.C. § 103.

Claims 9-11, 14, 18-19, 21 and 23 depend from claims 2, 17, 20 and 16 and recite additional features. It is respectfully submitted that the rejection of these claims would not have been anticipated or obvious within the meaning of 35 U.S.C. § 102(b) or under 35 U.S.C. § 103 at least for the reasons as set forth above. Therefore, it is respectfully

requested that the Examiner withdraws the rejection to claims 9-11, 14, under 35 U.S.C. § 102 and withdraws the rejection to claims 18, 19, 21 and 23 under 35 U.S.C. § 103.

Claims 1, 2, 5, 7, 9-11 and 14 were rejected under 35 U.S.C. § 102(e) as being anticipated by Lee (U.S. Patent No. 5,824,439).

Lee '439 appears to disclose referring to FIG. 1D, the light-shading layer 13 is etched using an etchant so that the light-shading layer 13 is etched in a sideward direction. As a result, the lower part of the phase shifting layer 17 is undercut. Here, the undercut part of the phase shifting layer becomes a phase shifting region and the part which is in contact with the light-shading layer 13 becomes a light-shading region. A part where the phase shifting layer 17 is not formed is a light-transmission region. (Col 2, lines 1-8) FIG. 3 is a cross-sectional view of a phase shifting mask. As shown in FIG. 3, a groove 37 is formed on a predetermined region of a transparent substrate 31 made of a transparent material, e.g., soda lime glass or quartz. A light-shading layer 39 is formed within the groove 37. The phase shifting layer 41 is formed so as to be in contact with the transparent substrate 31 at both sides of the groove 37, thereby limiting the light-shading layer 39 to be within the groove 37. (Col 4, lines 11-17, Col 5, lines 43-47). Referring to FIG. 4D, the sacrificial layer 33 is selectively removed using an etchant, e.g., H_3PO_4 , which has a high etch selectivity to the phase shifting layer 41, thereby exposing the transparent substrate 31. The exposed portion of the transparent substrate 31 becomes a light-transmission region. (Col 5, lines 50-55).

Thus, Lee '439 merely discloses in FIG. 1D a light shading layer 13 with etched sides and a phase shifting layer 17 which is undercut by the etching. There is nothing in

Fig. 1 of Lee '439 that shows, teaches or suggests a shade pattern formed in a hollow section of a transparent substrate and reflection preventing sections as claimed in claim 1. Furthermore, FIG. 3 of Lee '439 discloses a light shading layer 39 formed in groove 37; but phase shifting layer 41 is not a reflection preventing section, but is for phase shifting.

Furthermore, as shown in FIG. 1D of Lee '439, the phase shifting layer 17 is formed over the light-shading layer 13. Nothing in Lee '439 shows, teaches or suggests a planarized phase shift pattern as claimed in claims 2 and 5. Rather, Lee '439 merely discloses that the phase shifting layer 17 is formed over the light-shading layer 13.

Finally, nothing in Lee '439 shows, teaches or suggests a phase shift pattern formed by the transparent substrate as claimed in claim 7.

Since nothing in Lee '439 shows, teaches or suggests a) reflection preventing sections as claimed in claim 1, b) a planarized phase shift pattern as claimed in claims 2 and 5, and c) a phase shift pattern formed by transparent substrate as claimed in claim 7, it is respectfully requested that the Examiner withdraws the rejection to claims 1, 2, 5, and 7 under 35 U.S.C. § 102(e).

Claims 9-11 and 14 depend from claim 2 and recite additional features. It is respectfully submitted that claims 9-11 and 14 would not have been anticipated within the meaning of 35 U.S.C. § 102(e) at least for the reasons as set forth above. Therefore, it is respectfully requested that the Examiner withdraws the rejection to claims 9-11 and 14 under 35 U.S.C. § 102(e).

Claims 4 and 15 were rejected under 35 U.S.C. § 103 as being unpatentable over Hur et al. or Lee '439 in view of Lee et al. (U.S. Patent No. 6,017,659).

As discussed above, nothing in Hur et al. or Lee '439 show, teach or suggest a planarized phase shift pattern as claimed in claim 2 or the slope of a shifter edge section as claimed in claim 4.

Lee et al. appears to disclose a phase transition portion 73 having additive steps 5000, 500', 50" which is gradually formed along the border between the phase shifting region 75 and the transparent substrate 71, thereby gradualizing the phase shift and preventing the light intensity from being degraded at the phase shift border.

Thus, Lee et al. merely discloses a phase transition portion having steps formed along the border between a phase shifting region and a transparent substrate. Nothing in Lee et al. shows, teaches or suggests a planarized phase shift pattern as claimed in claim 2 or polishing the slope of a shifter edge section using chemical and mechanical polishing as claimed in claim 4.

Claim 4 depends from claim 2 and recites an additional feature of a difference of a step between the phase shift pattern and transparent substrate gradually decreases.

Claim 15 depends from claim 2 and recites an additional feature that the phase shift pattern includes a phase shift pattern having a shade pattern formed with a phase shifter and the shade pattern is applied to a large area section.

It is respectfully submitted that claims 4 and 15 would not have been obvious within the meaning of 35 U.S.C. § 103 over Hur et al. or Lee '439 and Lee et al. at least for the reasons as set forth above. Therefore, it is respectfully requested that the Examiner withdraws the rejection to claims 4 and 15 under 35 U.S.C. § 103.

Claims 3, 6 and 8 were rejected under 35 U.S.C. § 103 as being unpatentable over Hur et al. or Lee '439 in view of Lee (U.S. Patent No. 5,972,540).

As discussed above, nothing in Hur et al. or Lee '439 shows, teaches or suggests a) a planarized phase shift pattern as claimed in claim 2 and claim 5 or b) a phase shift pattern formed by the transparent substrate as claimed in claim 7. Furthermore, nothing in the references shows, teaches or suggests the slope of the edge section as claimed in claims 3, 6 and 8.

Lee '540 appears to disclose at column 5 lines 20-25 rectangular phase shifters 13A are heated and melted into hemispherical or rounded phase shifters 21 and thus phase shifters 22 are formed having planar top surfaces and round sidewalls.

Thus Lee '540 merely discloses phase shifters having round sidewalls formed by a reflow process from thermal heat treatment. Nothing in Lee '540 shows, teaches or suggests using chemical and mechanical polishing to form a slope at one edge section as claimed in claims 3, 6 and 8.

Claim 3 depends from claim 2 and recites an additional feature that the end section that is contacted to the transparent substrate has a sloped shape formed by chemical and mechanical polishing.

Claim 6 depends from claim 5 and recites an additional feature that the thickness of the end section gradually decreases due to chemical and mechanical polishing.

Claim 8 depends from claim 7 and recites an additional feature that the end section has a sloped shape formed by chemical and mechanical polishing.

It is respectfully submitted that claims 3, 6 and 8 would not have been obvious within the meaning of 35 U.S.C. § 103 over the references at least for the reasons as set forth above. Therefore, it is respectfully requested that the Examiner withdraws the rejection to claims 3, 6 and 8 under 35 U.S.C. § 103.

Claims 12 and 13 were rejected under 35 U.S.C. § 103 as being unpatentable over Hur et al. or Lee '439 in view of Tanabe (U.S. Patent No. 5,945,237).

As discussed above, nothing in Hur et al. or Lee '439 shows, teaches or suggests a planarized phase shift pattern selectively formed the shade pattern and transparent substrate as claimed in claim 2.

Tanabe appears to disclose in a halftone phase-shift mask, a phase-inverting light transmission part is formed inside the light-blocking part which blocks light that is radiated onto a transparent substrate so as to cover a shifter missing part defect, this phase-inverting light transmission part inverting the phase of light that passes through it with respect to light that passes through a light transmission part.

Thus, Tanabe merely discloses a half tone phase shift mask. Nothing Tanabe shows, teaches or suggests a planarized phase shift pattern selectively formed on the shade pattern and transparent substrate as claimed in claim 2.

Claim 12 depends from claim 2 and recites an additional feature that the phase shift pattern includes a half tone phase shift pattern.

Claim 13 depends from claim 2 and recites an additional feature that the phase shift pattern includes a half tone phase shift pattern with a shade pattern.

It is respectfully submitted that claims 12 and 13 would not have been obvious within the meaning of 35 U.S.C. § 103 over the references at least for the reasons as set forth above. Therefore, it is respectfully requested that the Examiner withdraws the rejection to claims 12 and 13 under 35 U.S.C. § 103.

Claims 16 and 24 were rejected under 35 U.S.C. § 103 as being unpatentable over Hur et al. in view of Mitsui (U.S. Patent No. 6,037,083).

As discussed above, nothing in Hur et al. shows, teaches or suggests a shade film and first and second reflection preventing films as claimed in claim 16.

Mitsui appears to disclose acid-resistant, highly reliable phase shift masks, and phase shift mask blanks, wherewith high-precision patterning is possible. A halftone phase shift mask blank comprising a transparent substrate 10, a halftone material film 11 laminated on that transparent substrate, and a metal film 12 laminated on that halftone material film, wherein the metal film is formed by a plurality of metal films having different etching rates, and the etching rate for the metal film positioned on the transparent substrate side is set so that it is faster, either in stages or continuously, than the etching rate of the metal film positioned on the surface side.

Thus, Mitsui merely discloses a metal film 12 laminated on a half tone material film where the metal film is formed by a plurality of metal films having different etching rates. Nothing in Mitsui shows, teaches or suggests forming a first reflection preventing film in each hollow section, forming a shade film on the first reflective preventing film, chemically and mechanically polishing this shade film to form a shade pattern and forming a second

reflective preventing film on this shade pattern as claimed in claim 16. Rather, Mitsui merely discloses a metal film of a plurality of layers laminated on a half tone material film.

The combination of Hur et al. and Mitsui would not be possible since nothing in Hur et al. shows, teaches or suggests forming a first reflective preventing film in a hollow section, forming a shade film on the first reflection preventing film, forming a shade pattern by chemical and mechanical polishing and forming a second reflection preventing film on the shade pattern as claimed in claim 16. Furthermore, nothing in Mitsui shows, teaches or suggests these features. Therefore, the combination of Hur et al. and Mitsui would not show, teach or suggest the invention as claimed in claim 16. It is therefore respectfully requested that the Examiner withdraws the rejection to claim 16 under 35 U.S.C. § 103.

Claim 24 depends from claim 16 and recites an additional feature that the radiation ray is one of an electron beaming from a laser beam and a monochromatic beam.

It is respectfully submitted that claim 24 would not have been obvious within the meaning of 35 U.S.C. § 103 over the references at least for the reasons as set forth above. Therefore, it is respectfully requested that the Examiner withdraws the rejection to claim 24 under 35 U.S.C. § 103.

As indicated above, new claims 27 and 28 have been added. It is respectfully submitted that these claims are also in condition for allowance.

Thus it now appears that the application is in condition for reconsideration and allowance. Reconsideration and allowance at an early date are respectfully requested.

If for any reason the Examiner feels that the application is not now in condition for allowance, it is respectfully requested that the Examiner contact, by telephone, the Applicants' undersigned attorney at the indicated telephone number to arrange for an interview to expedite the disposition of this case.

In the event that this paper is not timely filed within the currently set shortened statutory period, Applicants respectfully petition for an appropriate extension of time. The fees for such extension of time may be charged to our Deposit Account No. 02-4800.

In the event that any additional fees are due with this paper, please charge our Deposit Account No. 02-4800.

Respectfully submitted,

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